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U.S. ARMY ANTHROPOMETRIC SURVEY DATABASE: DOWNSIZING, DEMOGRAPHIC CHANGE, AND VALIDITY OF THE 1988 DATA IN 1996

by

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U.S. ARMY SOLDIER SYSTEMS COMMAND
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Anthropometric distributions of consumer groups, such as the U.S. Army, are to a large extent determined by their demographic composition. In fact, demographic change constitutes a primary driver of anthropometric changes over time and thus is a significant cause of anthropometric data base obsolescence. This study examines demographic change in the Active duty Army since 1988, when the U.S. Army Anthropometric Survey (ANSUR) was completed. The anthropometric consequences of these demographic shifts are modeled using weighted parameter estimates for common summary statistics, such as means and percentiles, and these 1995 parameter estimates are compared to their 1988 counterparts. Comparisons of 1988 and 1995 statistics suggest that although relatively large increases in the representation of females and racial minorities have occurred since 1988, these differences do not significantly impact Army-wide parameter estimates, perhaps because the groups changing most have low frequencies at the start. It is concluded that the ANSUR statistics reported in NATICK/TR-89/044 continue to be valid for anthropometric sizing and design in 1996.

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PREFACE

This study of demographic change in the active duty army and its impact upon the validity of the 1988 ANSUR database was undertaken during the period 1 Oct 95 - 29 Feb 96. The funding was Project OMA, Program Element 728012.12, and Work Unit OMA 1181.

The author thanks Zee Ferris of the Defense Manpower Data Center for her ongoing support of the many requests for demographic data that Natick's anthropology group generates in its research. Sarah Donelson contributed superb and timely data management support and statistical/editorial advice. Steve Paquette and Brian Corner provided invaluable technical reviews. Finally, the author would especially like to thank Marcia Lightbody, Natick's Technical Editor, for her dedication, technical skills and insight.

U.S. ARMY ANTHROPOMETRIC DATABASE: DOWNSIZING, DEMOGRAPHIC CHANGE, AND VALIDITY OF THE 1988 ANSUR DATA IN 1996

1. INTRODUCTION

Anthropometric distributions of consumer groups, such as the US Army, are to a large extent determined by their demographic composition. In fact, changes in the age, gender, and racial/ethnic composition of a group, such as those that occurred with the introduction of the "All Volunteer Force" (1), constitute a primary driver in anthropometric change over time, rivaling even that of secular increases in body size (2).

The 1988 US Army Anthropometric Survey (ANSUR) utilized a complex sampling strategy (3) to permit adaptation of the database to just such demographic shifts. Age, gender, and racial/ethnic strata were sampled independently to provide reference data on anthropometric differences among these groups, and to permit configuration of working databases that are demographically representative of contemporary military populations. While this strategy required measurement of more than 9000 soldiers, oversampling permits reconfiguration of design databases as Army demographics change, preventing premature obsolescence of anthropometric databases, which require multi-million dollar surveys to correct.

Representation of contemporary Army anthropometric distributions using the ANSUR database can be done in two primary ways: a) "dropping out" a demographically matched subset of the database using stratified random sampling methodology, or b) by employing weighted parameter estimation methods, which adjust the contribution of each subject in the database to match the prevailing frequencies of their demographic group. In 1989, when ANSUR data were first published (4), it was decided to use the matched subset technique so that published statistics could be associated with a file of individual subject data to be simultaneously released through the Defense Technical

Information Center/National Technical Information Service. By releasing only a ***representative*** subset of the ANSUR database, the Army ensured that potential users of these data did not inadvertently misuse or become confused by the availablility of oversampled data, whose summary statistics are essentially meaningless.

To ensure that Army design data remain "current", annual reviews of Active Duty Army demographics have been conducted with the help and support of the Defense Manpower Data Center (DMDC). Until last year, these reviews have indicated only minimal demographic change, which would be unlikely to impact anthropometric distributions. However, with aggressive downsizing of US military populations, substantial demographic change has been inevitable, and the 1994 and 1995 age/gender/race distributions are considerably different from those characterizing the 1988 Army population. One goal of this study is thus to quantify differences between the demographic distributions of the 1988 and 1995 Active duty Armies, and to model the influence of these demographic differences on anthropometric parameter estimates. The results of this research will be used to recommend what modifications, if any, are needed to ensure validity of the Army's design database, and what publications, if any, will need revision as a result.

Another goal of this study is to compare two alternative methods of creating and updating representative databases. Since 1988, when the ANSUR working databases were created and released, we have had the opportunity to create similar statistically matched working databases for the Canadian Forces and US Marine Corps, and to do small-scale anthropometric surveys to test the validity of these methods (5,6). In evaluating alternative statistical approaches for constructing matched databases, it has become increasingly apparent that individual ANSUR subjects in very low frequency demographic groups can have undue statistical influence on parameter estimates when they are randomly selected in the stratified sampling procedure used to create matched subsets.

The "sampling error" phenomenon that occurs in matched subset selection can be overcome by using a weighted parameter estimation method instead, where every ANSUR subject in the database is utilized, not just those selected randomly for inclusion in a matched subset. The weighted subject approach, which was recently utilized in creating USMC design databases (6), produces statistically superior parameter estimates but has a logistical limitation--there is no straightforward way to release individual subject data that correspond directly to the weighted summary statistics. It is important, therefore, to consider the practical significance of any theoretical superiority of weighted parameter estimation. This study approaches the question by comparing parameter estimates published in NATICK/TR-89/044 (4), which were based upon matched subsets of the ANSUR database, with weighted estimates based upon the same demographic templates, but using the entire ANSUR database, not just subsets.

2. MATERIALS AND METHODS

Demographic data utilized in this study were obtained from Defense Manpower Data Center (DMDC), in the form of age by race/ethnicity counts of the active duty army compiled separately for males and females, officers and enlisted soldiers (7,8). For the purposes of this analysis, officer and enlisted counts have been combined, gender counts have been kept separate, and age has been cast into five- year groupings with the exception of the youngest and oldest age categories, which are 17-20 years and 51-65 years (See Appendix B) . The youngest category is limited by age entrance regulations, which begin at 17, and the oldest category represents several five- year intervals pooled due to their small numbers. Racial/ethnic categories in this study match those of the DMDC, the ANSUR database, and those called for by Federal Regulation (9): White, Black, Hispanic, Asian/Pacific Islander (A/PI), Native American (NA), and Other.

Anthropometric data utilized in this study were obtained from the 1988 US Army Anthropometric Survey (ANSUR) database. The pilot subseries was not used because pilot body size distributions are influenced by airframe workstation limitations and

associated pilot entrance requirements. Subjects with excessive missing data were also eliminated from study -- particularly those with only head/face data.

Analytical weights (10) for each of the ANSUR subjects in this exercise were calculated as a function of their age/gender/race group, where: W=p(target population)/p(ANSUR database), and p is the relative frequency of subjects in that age/gender/race cell.

In order to keep the study to a manageable size, only 15 of the 132 ANSUR dimensions were examined. Stature and Weight were selected as indicators of overall body size. Sitting Height, Crotch Height, Span, and Thumbtip Reach were selected to represent relative trunk/limb proportions. Chest, Waist, and Buttock Circumference were selected for study due to their importance in clothing design and as indicators of relative enfleshment. Since head, hand, and foot dimensions are only modestly correlated with overall body size (11), variation in these body parts was studied using the following dimensions: Head Circumference, Breadth, and Length, Foot Length and Breadth, and Hand Circumference.

3. RESULTS

Demographic Comparisons:

Appendix A presents 1988 and 1995 Active duty Army demographics based upon data received from DMDC. As can be readily seen below in Table 1, whereas the total number of soldiers in today's Active duty Army has declined by approximately one third since 1988, the relative number of female soldiers has actually increased from 10.88% in 1988 to 13.31% in 1995.

Table 1. Gender Distribution in the Active Duty Army: 1988, 1995

	Males	Females	Total
1988	667,298 (89.12%)	81,486 (10.88%)	748,784 (100%)
1995	435,869 (86.69%)	66,918 (13.31%)	502,787 (100%)

Age distributions have also shifted considerably during downsizing, as can be seen in Figures 1 and 2 below. Both genders have relatively fewer 17-20 year olds in 1995 than they did in 1988, and females also have relatively fewer 20-25 and 26-30 year olds in 1995 than they did in 1988. In short, the contemporary Active duty population is older than it was in 1988. It should be noted that no statistical test is necessary to establish the significance of these differences, because the data below are not samples, but censuses of each population.

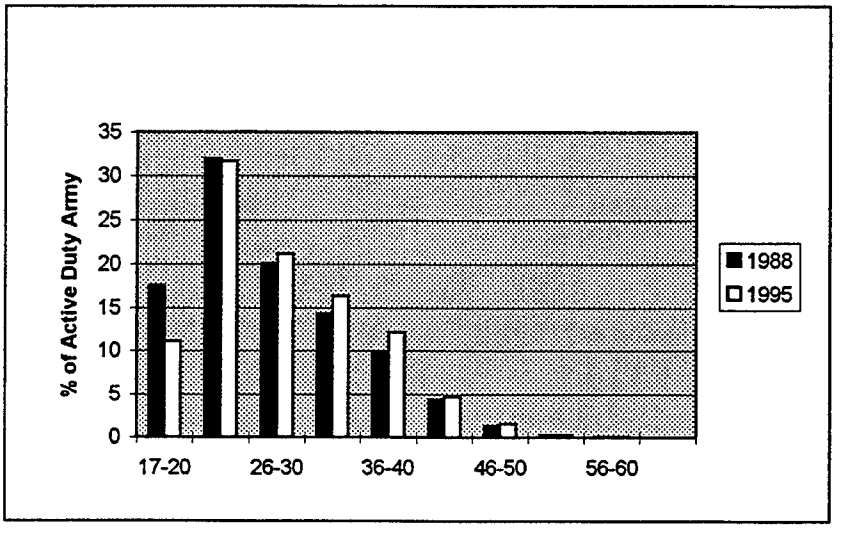

Figure 1. Male Age Distributions: 1988 vs. 1995

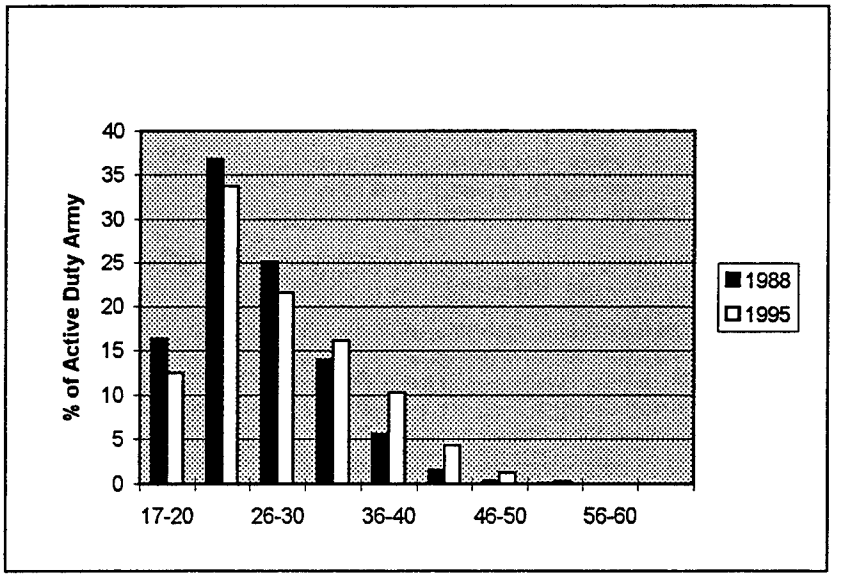

Figure 2. Female Age Distributions: 1988 vs. 1995

Racial/ethnic composition of the Active duty Army has also changed during downsizing, with relative frequencies of minority groups such as Hispanics and Asian/Pacific Islanders increasing 1-2 percentage points, as was predicted by Army recruiting forecasters (3).

Males	White	Black	Hispanic	A/PI	NA	Other
1988	66.21%	25.90%	3.89%	1.54%	0.45%	2.01%
1995	64.33%	24.66%	5.28%	2.15%	0.55%	3.03%
Females	**White**	**Black**	**Hispanic**	**A/PI**	**NA**	**Other**
1988	51.67%	41.75%	2.60%	1.46%	0.62%	1.90%
1995	45.97%	43.54%	4.26%	2.57%	0.78%	2.88%

Table 2. Racial/Ethnic Distributions in the Active Duty Army: 1988, 1995

It is particularly noteworthy that the gender differences in Army racial distributions identified and addressed in the 1988 ANSUR sampling strategy (3) have persisted in the 1995 Army. As can be seen below in Figure 3, Active duty females have almost equal

numbers of White and Black soldiers, whereas White Active duty males greatly outnumber Black Active duty males.

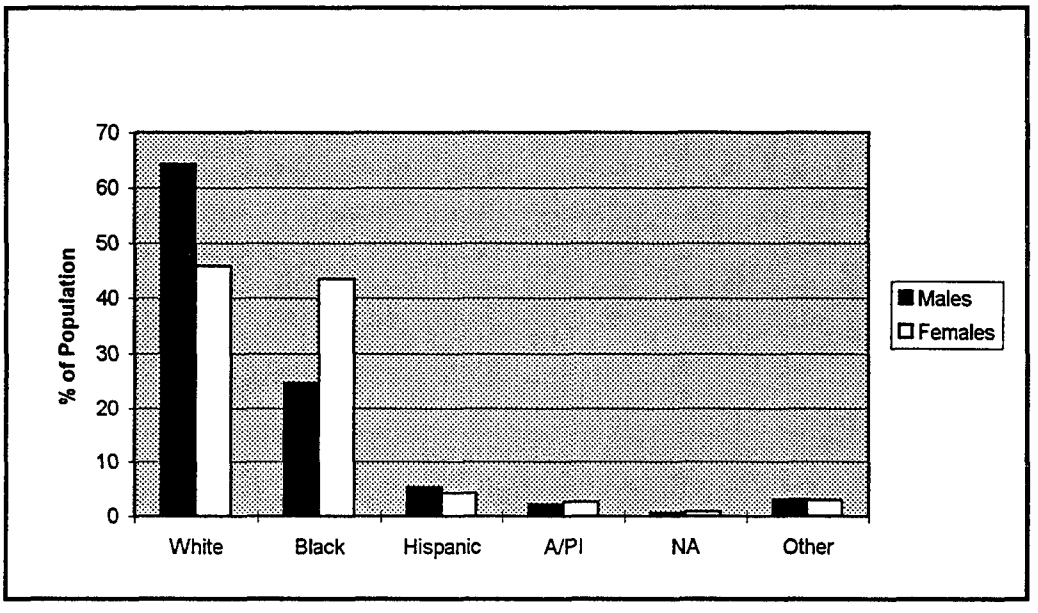

Figure 3. 1995 Racial/Ethnic Distributions in the Active Duty Army

Impact of Demographic Changes on Army Anthropometry:

To examine the extent of anthropometric change expected as a result of the observed demographic shifts between 1988 and 1995, we calculated weighted parameter estimates using 1988 and 1995 DMDC age/race distributions. These statistics are reported in their entirety at Appendix B. Comparison of weighted estimates for the 1988 and 1995 Active duty Armies with those published in ANSUR technical reports and military standards (4,12,13) is done in the following table for the variables stature and weight.

Table 3. Body Size Parameter Estimates for 1988 and 1995 Active Duty Armies

MALES		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Stature (mm)	TR-89/044	1774	1497	1603	1647	1755.8	66.8	1866	1909	2042
	1988	5015	1497	1605	1647	1756.9	67.1	1868	1912	2042
	1995	5015	1497	1601	1644	1755.5	67.7	1868	1912	2042
Weight (kg)	TR-89/044	1774	47.6	55.3	61.6	78.5	11.1	98.1	107.7	127.8
	1988	5015	45.2	56.2	62.1	78.8	11.2	98.8	108.2	133.3
	1995	5015	45.2	56.2	62.1	79.1	11.2	99.1	108.3	133.3
FEMALES		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Stature (mm)	TR-89/044	2208	1428	1483	1528	1629.4	63.6	1737	1780	1870
	1988	3481	1413	1485	1528	1629.5	63.7	1738	1781	1870
	1995	3481	1413	1484	1525	1628.2	64.2	1738	1780	1870
Weight (kg)	TR-89/044	2208	41.3	45.2	49.6	62.0	8.4	77.0	84.7	96.7
	1988	3482	38.9	45.5	49.6	61.9	8.3	76.9	84.0	99.5
	1995	3482	38.9	45.5	49.7	62.3	8.7	78.0	85.2	99.5

Table 3 presents three sets of parameter estimates for Active duty soldiers' height and weight: The first set listed was estimated using the matched subset method, and is published in the ANSUR final report (4): NATICK TR-89/044; the second set of parameter estimates was derived from exactly the same 1988 demographic distributions as the first, but was calculated by using individual subject weights for the entire database; the third set of parameter estimates was also derived using individual subject weights, but the weights were calculated using 1995 demographic distributions.

As can be readily seen by comparing the first two lines for each variable, the subset method of parameter estimation always results in lower sample sizes, and often fails to identify the true minimum and maximum values observed in the ANSUR survey because these subjects are not always included in the randomly selected subset. Nevertheless, the absolute differences between the percentiles, means and standard deviations based upon the subset method vs. the weighted subject method are negligible. This result is exactly as expected given the relatively large sample sizes of the matched subsets (n=1774 males and

2208 females), which are more than adequate for design purposes. As can be seen in Appendix B, these same results hold for the other anthropometric variables in this study.

Comparison of the second and third lines for each variable in Table 3 provides an estimate of the height and weight distribution changes expected as a result of demographic differences in the 1988 and 1995 Active duty Armies. And, as can be readily seen, height and weight statistics estimated for the 1995 Active duty Army are only slightly different from the 1988 figures. These results are mirrored in the other 13 anthropometric variables presented at Appendix B. None of the 1988-1995 differences exceed measurement error magnitudes (4,14), which appear in Appendix C for comparison.

Table 4. Circumferential Differences: 1988 vs. 1995
(All Values in mm)

Males		**1st %ile**	**5th %ile**	**Mean**	**(sd)**	**95th %ile**	**99th %ile**	**Obs Error**
Chest Circ	1988	852	889	993.7	69.5	1116	1173	7-15
	1995	852	891	997.1	70.1	1119	1180	
Waist Circ (O)	1988	704	736	864.3	87.7	1021	1083	4-12
	1995	704	740	870.2	88.1	1024	1086	
Buttock Circ	1988	851	890	985.1	62.2	1091	1139	4-12
	1995	851	890	987.2	62.8	1094	1142	
Females		**1st %ile**	**5th %ile**	**Mean**	**(sd)**	**95th %ile**	**99th %ile**	**Obs Error**
Chest Circ	1988	785	813	906.3	63.1	1018	1076	6-15
	1995	785	814	910.3	66.1	1028	1088	
Waist Circ (O)	1988	645	675	790.6	82.1	943	1020	6-12
	1995	645	677	798.0	85.8	961	1027	
Buttock Circ	1988	842	873	966.1	60.7	1068	1126	4-12
	1995	842	874	969.5	62.6	1076	1131	

The largest differences between 1988 and 1995 parameter estimates for both males and females occur in the chest, waist and buttock circumference variables. These are presented above in Table 4 because they bear watching in the future if current demographic trends continue. However, none of these differences is large enough to substantially impact design and sizing of Army materiel at this time.

4. DISCUSSION

Demographic data on the Active duty Army indicates that downsizing to date has been accompanied by slight increases in the retention/recruitment of females, certain minority groups (Hispanics and Asians, for example), and older age groups. Although representative increases in these demographic subgroups are substantial relatively speaking, since none of the groups comprises a large portion of the Army, the impact of these groups on anthropometric distributions of the Army as a whole is minimal. Indeed, comparisons of the weighted 1988 and 1995 anthropometric distributions suggest that only very small anthropometric differences may have arisen as a consequence of demographic shifts. The magnitudes of these anthropometric differences are not only well below materiel manufacturing tolerances, they are also smaller than the average measurement errors of trained anthropometrists. Given this, one can safely conclude that the 1988 ANSUR anthropometric distributions are still valid for materiel design and sizing in 1995.

Whereas the age/race demographic shifts studied here seem to have little impact on primary design & sizing statistics (which are estimated and applied separately for males and females in practice), increased female representation in the 1995 Army does have a secondary impact on the purchasing and stocking tariffs of military clothing and equipment that is shared by men and women, since presumably more "smaller, shorter" sizes will be required to accommodate the women, and more alterations will be needed when off-the-shelf sizes do not fit them. Effective immediately, all anthropometric tariffs estimated

using weighted male and female data should employ relative frequencies of 13.3% females and 86.7% males.

Finally, several caveats are appropriate. Firstly, the weighted estimation method of calculating anthropometric parameters from the ANSUR database assumes that the anthropometric distributions of the age/gender/race subgroups are in a steady state. This assumption holds well when secular changes in body size are small, and the elapsed time between the database (1988) and the target population (in this study, 1995) is short. Since previously published research on US Army secular trends (2,15,16,17) has shown that rates of change over time are small and getting smaller in Black and White soldiers (who together comprise more than 90% of the Army), this assumption seems tenable for the purposes of this study.

It should be noted, however, that the most pronounced of the small secular trends identified after the 1988 survey were in body circumferences, and the most substantial secular increases/decreases in body size were present in the same demographic groups that are increasing in frequency during the downsizing: Hispanics and Asians (17). Perhaps these are just coincidences, but since circumferences seem to be most sensitive to the demographic changes modeled in this study, and since they are also associated with secular trends and particularly so in racial minority groups, the combined effects of these factors on anthropometric variables should be tracked carefully in the coming years. This can be done most efficiently by conducting a 10-15 dimension mini-survey that can then be used to validate/update Army secular trend models and provide an independent baseline against which to validate weighted parameter estimation methods using the ANSUR database.

A second caveat regarding all studies of demographic change in the Army has to do with the frequency of racial/ethinic misclassification present in official data. A great deal of research has been done in this area as it pertains to analyses and interpretations of official US Census data (for example, reference 18), and our own research on U.S. Army

racial/ethnic identifications indicate that the problem is substantial for soldiers in the Hispanic, Asian/PI, and Native American groups, but virtually nonexistent for White and Black soldiers (19). Thus our "official" estimates of the relative frequency of soldiers is least accurate in those group experiencing the most demographic change and the strongest ongoing secular trends. This reinforces the need for a mini-survey in 1998 to validate our current anthropometric models, and to study once again the nature and extent of underestimation of minority groups. If a second study in 1998 uncovers underestimation rates similar to those observed in 1988, we may want to consider routinely adjusting DMDC data when it is used in weighting anthropometric databases.

A third caveat regarding the applicability of this research concerns the fact that anthropometric databases and design standards have traditionally assumed the Active duty Army as the primary target population. While this may have been an easy decision before, current "Force XXI" vision relies upon force projection that is achieved through a smaller standing Army and strategic activation of Reserve units. In point of fact, Reserve units are *essential* to today's military effectiveness. This suggests that we should re-examine our traditional assumptions about the appropriateness of the Active duty Army serving as the design template for Army materiel. At the very least, we should be tracking Reserve demographics and modeling their anthropometric distributions so that we can see how different they are -- if they are different at all from the Active duty population. So while it is clear that there are no substantial reasons to change anthropometric design standards due to shifts in the Active Duty population, the shift in reliance upon the Reserve population suggests that more attention needs to be paid to the anthropometric distributions of the latter.

5. RECOMMENDATIONS

a. No revision of Army design standards or anthropometric publications are recommended at this time.

b. Anthropometric tariff calculations should, however, utilize an 86.7% male and 13.3% female weighting ratio.

c. A mini-survey of the Active Duty Army should be executed in the 1998 timeframe to:

1) establish whether or not secular changes in body size distributions within age/gender/race groups have occurred;

2) confirm the validity of ongoing use of anthropometric parameter estimates based upon data collected during the 1988 ANSUR survey;

3) determine whether or not the consistent under-identification of racial minorities in the 1988 official records has persisted.

d. Characterization of the demographic and anthropometric composition of the Army Reserve populations should be undertaken in FY97 using whatever data already exist in DoD databases. The results of these analyses should be used to determine whether Reserve units will be included in a 1998 mini-survey, and how their data should impact military design standards and procurement documents.

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APPENDIX A

ACTIVE DUTY ARMY DEMOGRAPHICS: 1988 vs. 1995

Table A-1. US Army Active Duty Population: 1988

Males	White	Black	Hispanic	A/PI	NA	Other	Total
17-20	84420	25280	3926	1374	590	1951	117541
21-25	142622	55959	7357	2783	1066	4155	213942
26-30	80189	41826	6047	2051	480	3307	133900
31-35	57626	28529	4689	1867	380	2256	95347
36-40	46645	13918	2684	1316	340	1196	66099
41-45	21827	5273	963	623	131	454	29271
46-50	6597	1800	245	193	26	93	8954
51-55	1607	221	46	35	7	18	1934
56-60	237	13	5	7	0	4	266
61-65	42	0	0	0	0	2	44
Total	441812	172819	25962	10249	3020	13436	667298

Females	White	Black	Hispanic	A/PI	NA	Other	Total
17-20	7711	4785	355	176	98	225	13350
21-25	15417	12689	742	367	218	581	30014
26-30	9443	9728	517	279	96	393	20456
31-35	5709	4876	314	212	55	230	11396
36-40	2673	1541	138	104	33	85	4574
41-45	850	336	40	31	4	28	1289
46-50	222	64	10	12	2	5	315
51-55	61	3	1	4	1	2	72
56-60	14	1	0	0	0	3	18
61-65	1	0	0	1	0	0	2
Total	42101	34023	2117	1186	507	1552	81486

Table A-2. US Army Active Duty Population: 1995

Males	White	Black	Hispanic	A/PI	NA	Other	Total
17-20	34481	8802	3117	998	303	832	48533
21-25	93425	30025	6944	2978	837	3822	138031
26-30	58366	24383	4199	1863	475	3040	92326
31-35	42721	20601	3816	1455	373	2605	71571
36-40	29491	17019	3207	1127	256	1932	53032
41-45	14346	5280	1320	581	119	729	22375
46-50	6172	1161	353	259	42	213	8200
51-55	1172	180	58	80	2	33	1525
56-60	174	15	11	19	1	6	226
61-65	40	2	3	4	0	1	50
Total	280388	107468	23028	9364	2408	13213	435869

Females	White	Black	Hispanic	A/PI	NA	Other	Total
17-20	4397	2938	504	239	105	169	8352
21-25	10651	9371	1054	647	167	693	22583
26-30	6140	6878	513	345	110	424	14410
31-35	4433	5363	374	225	66	325	10786
36-40	2985	3224	262	157	47	188	6863
41-45	1543	1060	98	63	20	82	2866
46-50	482	256	41	33	4	31	847
51-55	120	45	3	9	3	11	191
56-60	12	1	0	5	0	1	19
61-65	1	0	0	0	0	0	1
Total	30764	29136	2849	1723	522	1924	66918

APPENDIX B

ANTHROPOMETRIC PARAMETER ESTIMATES FOR ACTIVE DUTY MALES AND FEMALES

Table B-1. Anthropometric Parameter Estimates for Active Duty Males: 1988, 1995
(all values in mm; weight in kg)

		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Stature (mm)	TR-89/044	1774	1497	1603	1647	1755.8	66.8	1866	1909	2042
	1988	5015	1497	1605	1647	1756.9	67.1	1868	1912	2042
	1995	5015	1497	1601	1644	1755.5	67.7	1868	1912	2042
Weight (kg)	TR-89/044	1774	47.6	55.3	61.6	78.5	11.1	98.1	107.7	127.8
	1988	5015	45.2	56.2	62.1	78.8	11.2	98.8	108.2	133.3
	1995	5015	45.2	56.2	62.1	79.1	11.2	99.1	108.3	133.3
Sitting Height	TR-89/044	1774	808	828	854	913.9	35.6	972	991	1032
	1988	5011	779	830	855	913.9	35.8	972	993	1041
	1995	5010	779	829	854	913.8	36.0	972	993	1041
Crotch Height	TR-89/044	1774	675	732	764	837.2	46.2	916	946	1067
	1988	5014	660	730	763	837.7	46.4	915	948	1067
	1995	5014	660	729	761	836.0	46.5	914	947	1067
Span	TR-89/044	1774	1474	1648	1693	1823.1	81.9	1960	2016	2159
	1988	4985	1474	1638	1692	1824.1	81.6	1960	2015	2159
	1995	4980	1474	1635	1690	1822.5	81.9	1959	2013	2159
Thumbtip	TR-89/044	1774	662	720	739	800.8	39.2	867	897	980
Reach	1988	4986	648	714	740	801.6	39.1	865	895	980
	1995	4981	648	712	740	801.4	39.3	865	894	980
Chest	TR-89/044	1774	775	845	886	991.4	69.0	1113	1168	1281
Circumference	1988	5015	775	852	889	993.7	69.5	1116	1173	1330
	1995	5015	775	852	891	997.1	70.1	1119	1180	1330
Waist	TR-89/044	1774	654	696	733	862.4	86.4	1016	1077	1185
Circumference	1988	5015	640	704	736	864.3	87.7	1021	1083	1281
(Omphalion)	1995	5015	640	704	740	870.2	88.1	1024	1086	1281
Buttock	TR-89/044	1774	805	848	886	983.7	62.2	1090	1136	1239
Circumference	1988	5013	801	851	890	985.1	62.2	1091	1139	1286
	1995	5014	801	851	890	987.2	62.8	1094	1142	1286

(continued)

Table B-1. Anthropometric Parameter Estimates for Active Duty Males, Continued

		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Head Circumference	TR-89/044	1774	514	533	543	567.7	15.4	594	606	627
	1988	5013	514	534	543	568.0	15.6	594	607	633
	1995	5012	514	534	543	568.2	15.8	595	607	633
Head Breadth	TR-89/044	1774	128	139	143	151.7	5.4	161	165	173
	1988	5013	128	140	143	151.7	5.5	161	165	175
	1995	5012	128	140	143	151.9	5.5	161	165	175
Head Length	TR-89/044	1774	173	180	185	197.1	7.1	208	213	220
	1988	5013	165	181	186	197.2	7.0	208	213	224
	1995	5012	165	180	185	197.1	7.1	209	213	224
Foot Length	TR-89/044	1774	228	240	249	269.7	13.1	292	302	310
	1988	4992	223	240	249	270.0	13.1	292	301	318
	1995	4987	223	240	248	269.7	13.2	292	302	318
Foot Breadth, Horizontal	TR-89/044	1774	80	89	92	100.6	5.3	110	114	122
	1988	4991	80	89	92	100.8	5.3	110	114	123
	1995	4986	80	89	92	100.8	5.4	110	115	123
Hand Circumference	TR-89/044	1774	182	192	198	213.8	9.7	230	237	247
	1988	5013	178	193	198	214.1	9.6	230	237	255
	1995	5012	178	192	198	214.2	9.8	230	237	255

Table B-2. Anthropometric Parameter Estimates for Active Duty Females: 1988, 1995
(all values in mm; weight in kg)

		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Stature (mm)	TR-89/044	2208	1428	1483	1528	1629.4	63.6	1737	1780	1870
	1988	3481	1413	1485	1528	1629.5	63.7	1738	1781	1870
	1995	3481	1413	1484	1525	1628.2	64.2	1738	1780	1870
Weight (kg)	TR-89/044	2208	41.3	45.2	49.6	62.0	8.4	77.0	84.7	96.7
	1988	3482	38.9	45.5	49.6	61.9	8.3	76.9	84.0	99.5
	1995	3482	38.9	45.5	49.7	62.3	8.7	78.0	85.2	99.5
Sitting Height	TR-89/044	2208	748	775	795	852.0	34.9	910	933	971
	1988	3481	735	774	795	852.0	34.8	911	933	971
	1995	3481	735	774	795	851.0	34.5	910	931	971
Crotch Height	TR-89/044	2208	594	670	700	771.4	44.1	846	881	948
	1988	3480	594	670	702	771.5	44.3	845	880	957
	1995	3480	594	669	699	770.6	45.0	846	880	957
Span	TR-89/044	2208	1356	1488	1542	1672.0	81.3	1809	1864	1968
	1988	3471	1356	1483	1546	1671.8	81.2	1806	1868	1996
	1995	3466	1356	1484	1545	1672.7	82.4	1810	1869	1996
Thumbtip Reach	TR-89/044	2208	605	658	677	734.6	36.4	797	824	898
	1988	3473	605	658	676	734.6	36.7	796	824	898
	1995	3471	605	658	676	735.5	37.5	800	825	898
Chest Circumference	TR-89/044	2208	711	781	814	907.1	63.5	1022	1077	1176
	1988	3482	711	785	813	906.3	63.1	1018	1076	1222
	1995	3482	711	785	814	910.3	66.1	1028	1088	1222
Waist Circumference (Omphalion)	TR-89/044	2208	610	644	676	791.9	82.7	946	1026	1108
	1988	3482	608	645	675	790.6	82.1	943	1020	1108
	1995	3482	608	645	677	798.0	85.8	961	1027	1108
Buttock Circumference	TR-89/044	2208	787	841	872	966.9	60.2	1070	1124	1189
	1988	3480	780	842	873	966.1	60.7	1068	1126	1196
	1995	3480	780	842	874	969.5	62.6	1076	1131	1196

(continued)

Table B-2. Anthropometric Parameter Estimates for Active Duty Females, Continued

		n	Min	1st %ile	5th %ile	Mean	(sd)	95th %ile	99th %ile	Max
Head Circumference	TR-89/044	2208	500	513	522	546.2	14.6	570	584	611
	1988	3482	489	513	523	546.1	14.8	570	585	615
	1995	3482	489	513	523	546.6	15.1	571	586	615
Head Breadth	TR-89/044	2208	126	133	137	144.4	4.9	153	157	167
	1988	3482	126	133	136	144.4	4.9	153	157	172
	1995	3482	126	133	137	144.7	5.1	153	158	172
Head Length	TR-89/044	2208	158	172	176	187.2	6.4	198	202	211
	1988	3482	158	171	176	187.1	6.5	198	202	215
	1995	3482	158	171	176	187.0	6.6	198	202	215
Foot Length	TR-89/044	2208	203	217	224	244.4	12.2	265	272	290
	1988	3471	203	217	224	244.3	12.1	264	271	290
	1995	3469	203	217	224	244.5	12.3	265	273	290
Foot Breadth, Horizontal	TR-89/044	2208	73	79	82	89.7	4.9	98	102	109
	1988	3471	73	79	82	89.6	4.9	98	102	109
	1995	3469	73	79	82	89.8	4.9	98	103	109
Hand Circumference	TR-89/044	2208	158	167	172	186.2	8.5	200	207	230
	1988	3482	155	168	172	186.1	8.5	200	208	230
	1995	3482	155	168	173	186.4	8.6	201	209	230

APPENDIX C

Table C-1. Anthropometric Measuring Error (to nearest mm)

	ANSUR Team (male subjects)	ANSUR Team (female subjects)	Criterion Experts
Stature	3	3	11
Sitting Height	3	3	6
Crotch Height	6	4	10
Span	7	7	10
Thumbtip Reach	11	10	20
Chest Circumference	7	6	15
Waist Circ (O)	4	6	12
Buttock Circumference	4	4	12
Head Circumference	1	1	5
Head Breadth	1	1	2
Head Length	1	1	2
Foot Length	1	1	3
Foot Br, Horizontal	1	1	2
Hand Circumference	1	1	4